Experimental Road Weather Forecasting in Hungary

André Simon, Zsolt Szarka

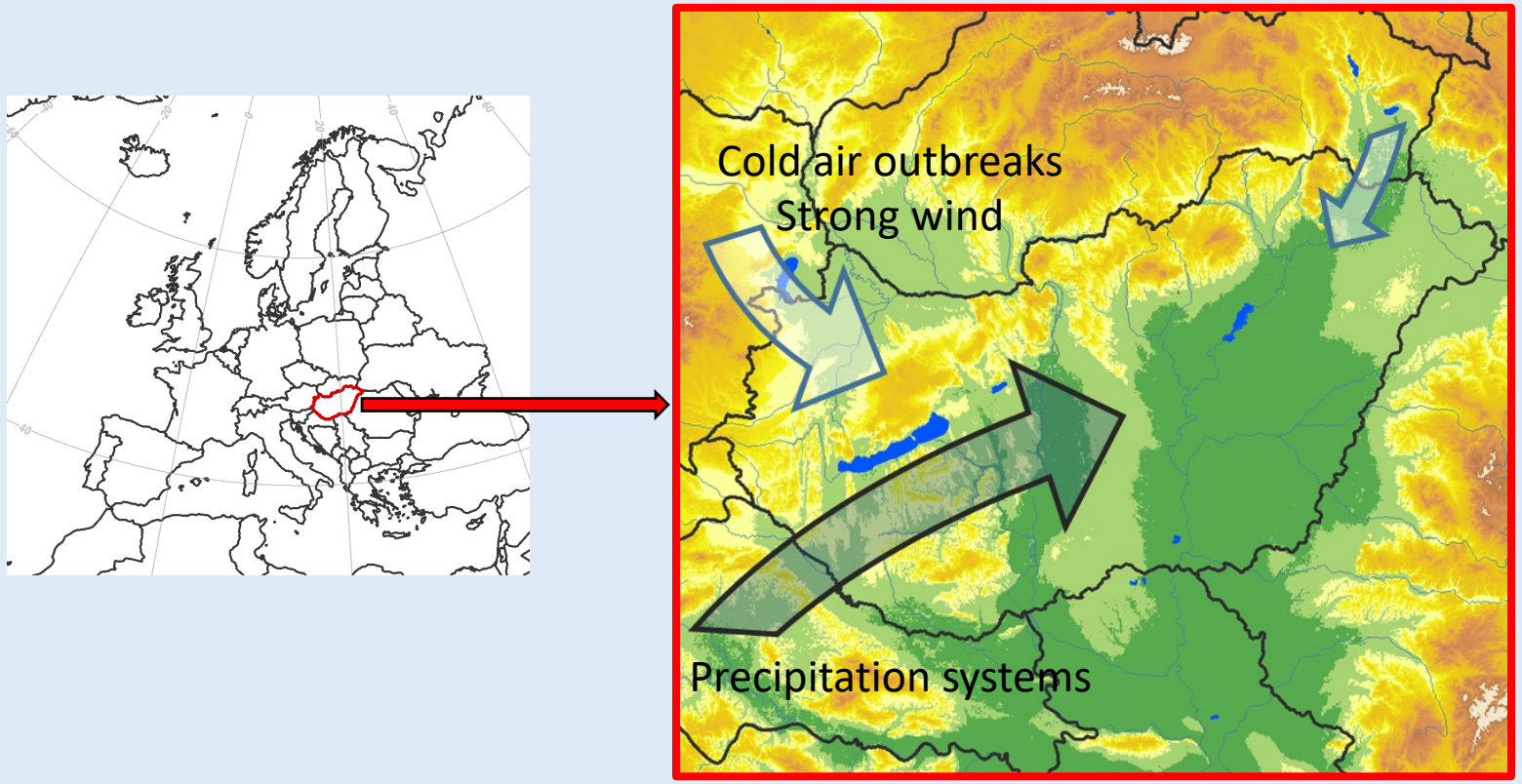
Hungarian Meteorological Service

Hungarian Public Road Nonprofit PLC

19th SIRWEC conference, Smolenice, Slovakia, 29 May – 01 June 2018

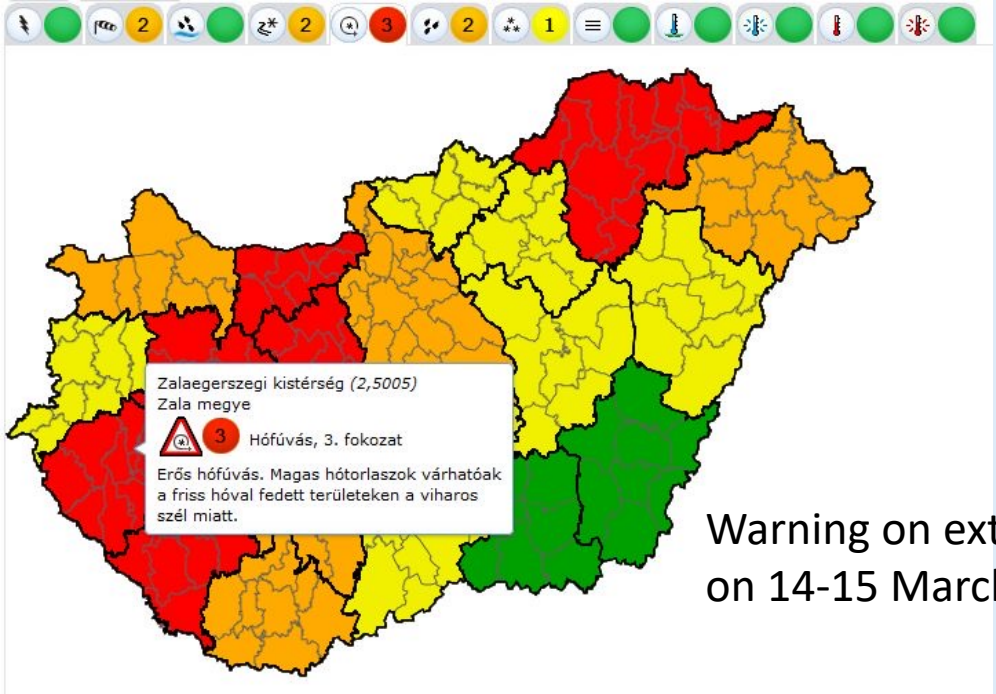
Winter weather conditions in Hungary

- Typically mild, rather continental climate but frequent periods with cold temperature (below 0°C), snow or freezing rain
- Not entirely plain country, hills (200-1000m ASL) and forests covering significant area
- Mediterranean cyclones+ cold air outbreaks: heavy snowfall and blowing snow events



Road forecasting and severe weather warning

- Long cooperation between the national meteorological service (OMSZ), the Hungarian Public Road PLC and the motorway operating companies (e.g. A-WAY)
- Meteorological parameters, forecasts and warnings provided
- National weather warnings on heavy snowfall, blowing snow, freezing rain, etc.



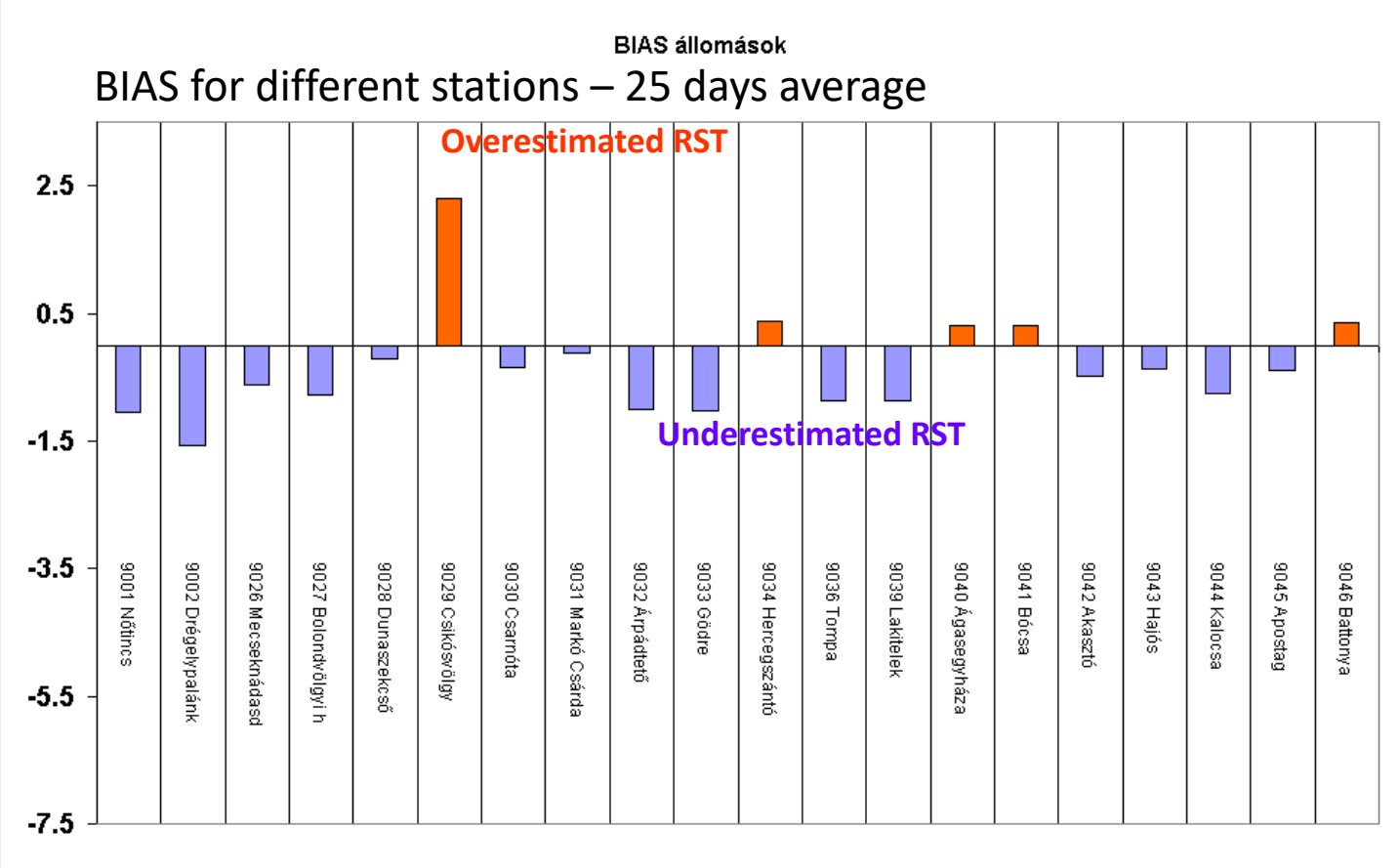
Warning on extreme blowing snow event on 14-15 March 2013

Experimental road surface temperature forecasts

- METRo road forecasting model, version 3.2.7 (Crevier, Delage, 2001)
- Road Weather Stations (RWS) of the Hungarian Public Road and M5 motorway
- ECMWF and WRF input data (9 and 2.5 km horizontal resolution), 8h coupling period and 24h forecasts (starting at 00 UTC)
- Statistical evaluation (25 days in December 2014), 165 RWS, ECMWF data
- Case studies, sensitivity tests

BIAS – evaluation (December 2014, usual winter conditions in Hungary)

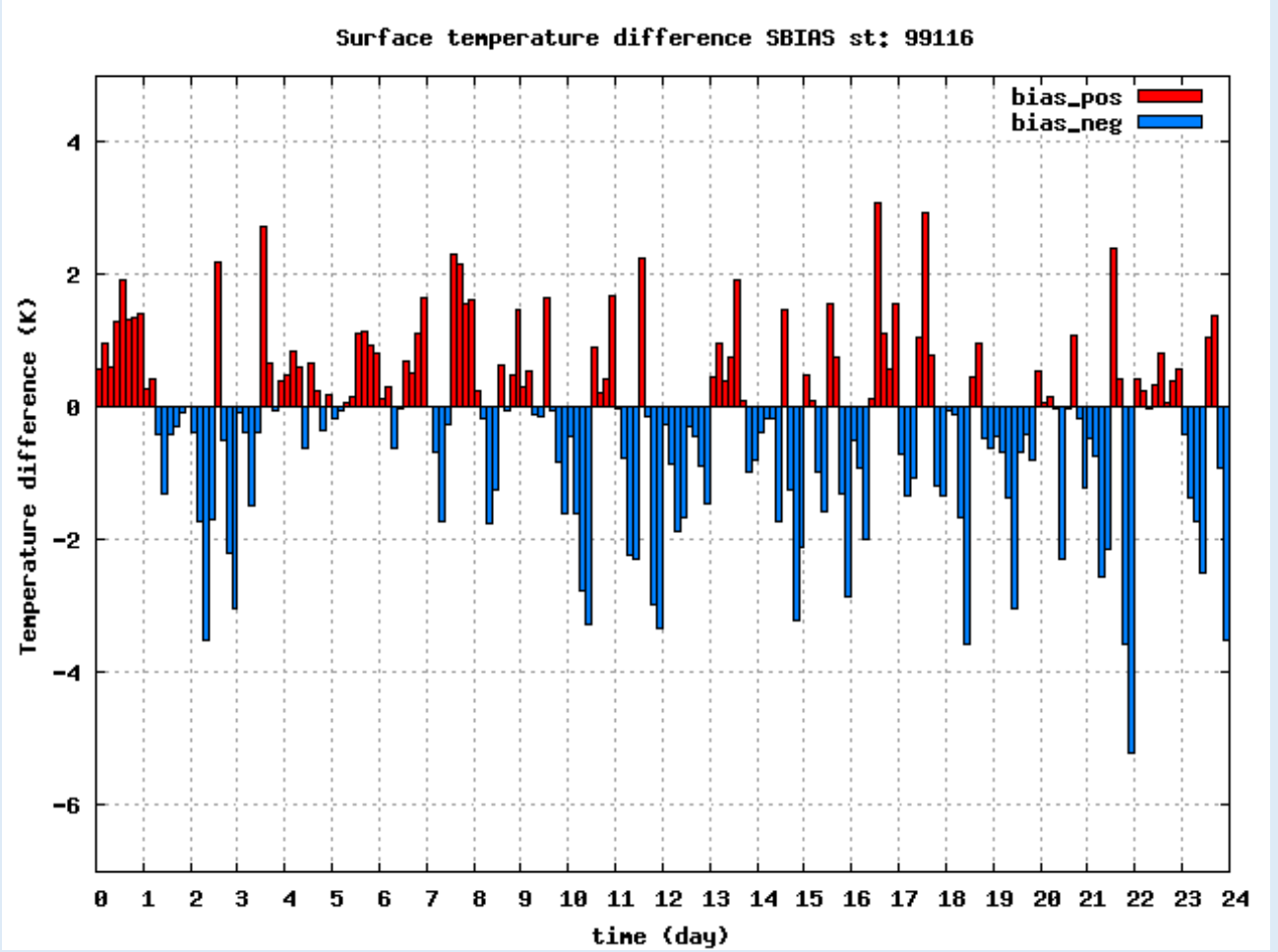
- Road surface temperature (RST) underestimated at 113, overestimated at 47 stations
- Difference between the forecast and observed RST is –0.3 °C (mostly underestimation)



BIAS day-to-day changes

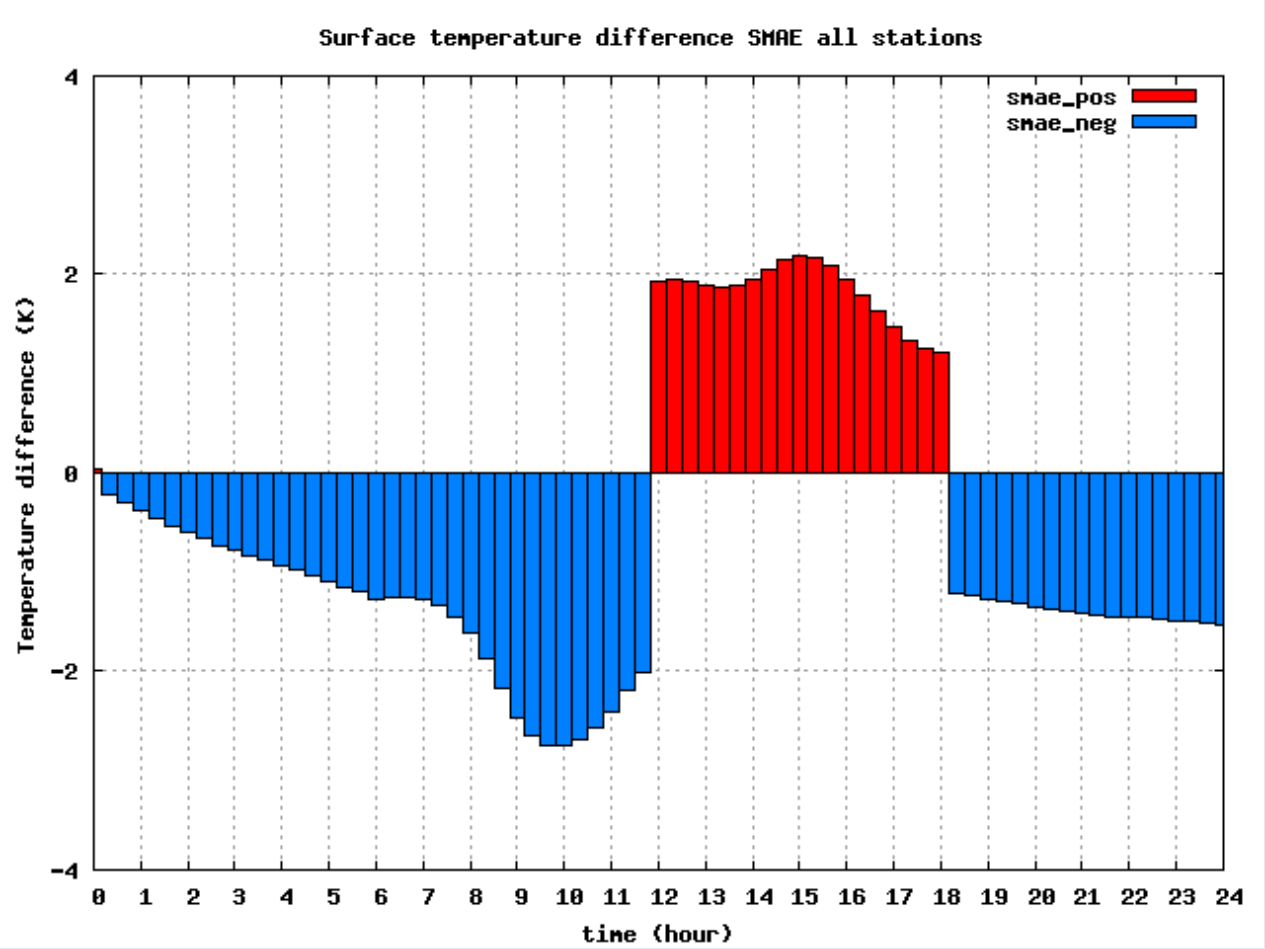
- The forecast error depends on the period of the day (systematic, local error) and on the weather situation

Example:
Course of the forecast road surface temperature BIAS at the station Szolnok (eastern Hungary), December 2014



BIAS and MAE - daily course

• The temperature is underestimated in the morning/evening, overestimation is around noon. These errors are rather systematic, sometimes arise from time-delays in the input model forecasts (cloudiness, radiation)



MAE/RMSE – averages for all stations and whole period

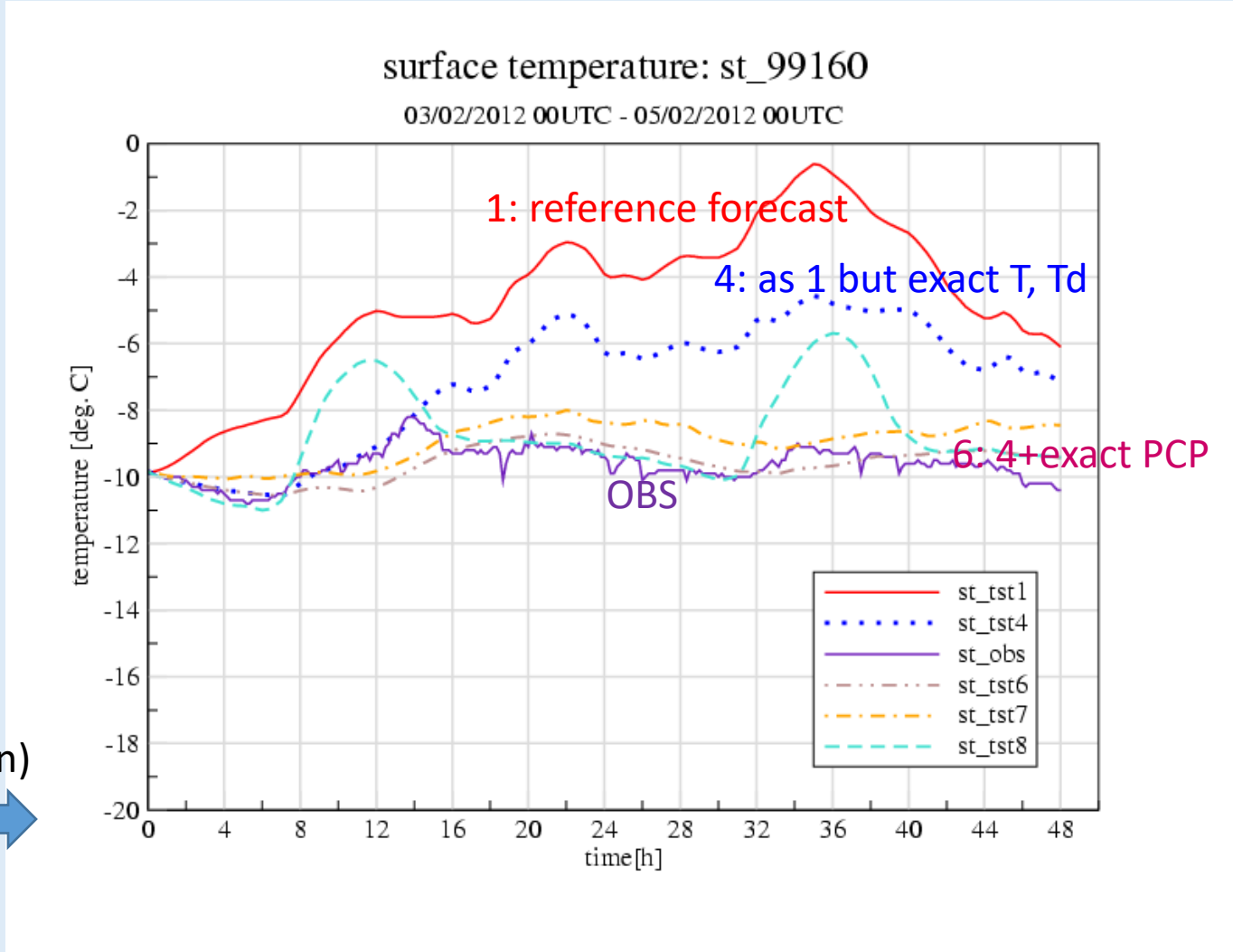
- **MAE < 1,5°C at 94 stations**
- **RMSE < 2°C at 86 stations**

OBS source: **Input NWP model:**	**OMSZ/Hungarian Public Road data** **ECMWF model, December 2014**	**OMSZ/M5 motorway data** **WRF model, 2 weeks in January/February 2012**	**Publications** **Various road weather forecast systems abroad**	**OMSZ/operational verification** **ECMWF**
Forecast parameter	**Road surface temperature**	**Road surface temperature**	**Road surface temperature**	**NWP 2m temperature**
MAE	**1.48**	**1.12**	**1.0-4**	**1.0-2.5**
RMSE	**2.12**	**1.55**	**1.3-6**	**1.1-2.7**

Sensitivity tests

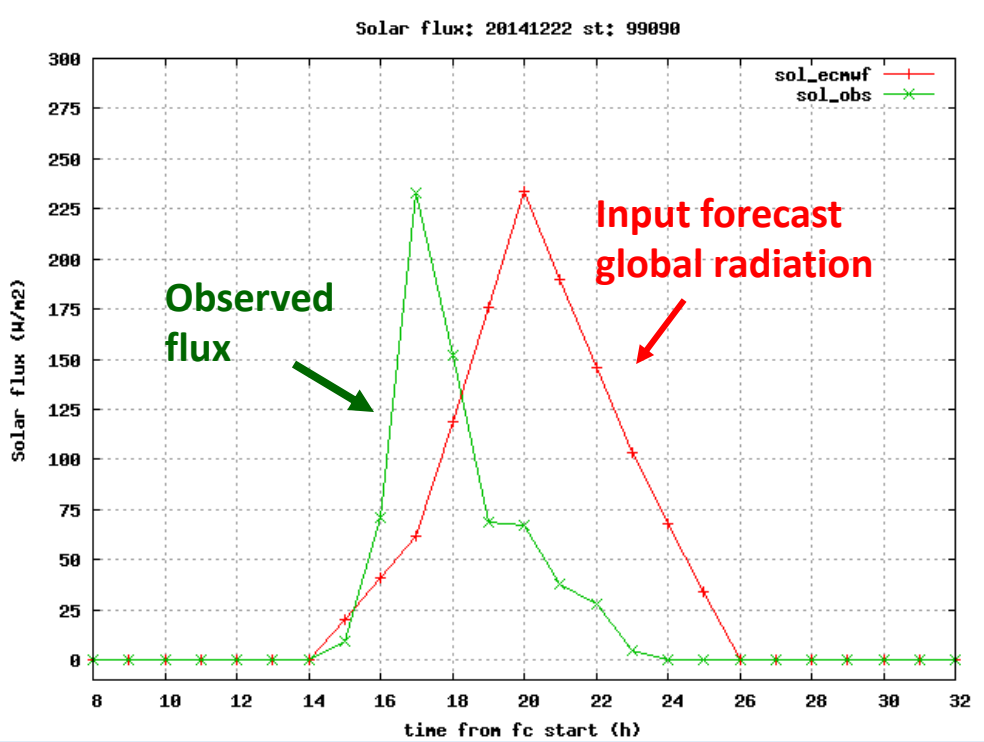
- The road surface temperature forecast is very sensitive on the precision of NWP inputs
- Sometimes high forecast errors can be related to delays or displacements of precipitation bands, errors in the precipitation-type determination, etc.
- Exact input data (close to OBS) result in similar temperature course as observed

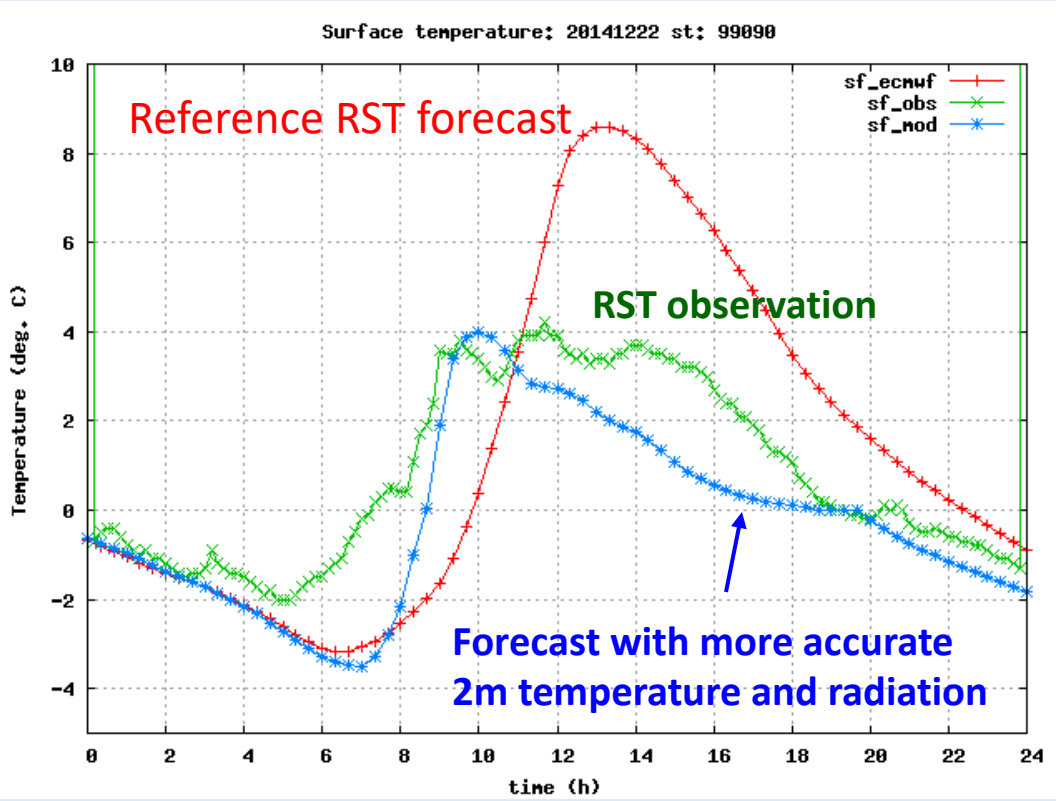
Sensitivity test on road temperature forecast
(METRo model coupled with WRF, M5 motorway station)
Forecast for Szeged (southeast Hungary)



Sensitivity on radiation/cloudiness forecast

- In this example we replaced the forecast global radiation flux (from the ECMWF) with the one observed at the nearby OMSZ meteorological station
- As a result we obtained more accurate road surface temperature course





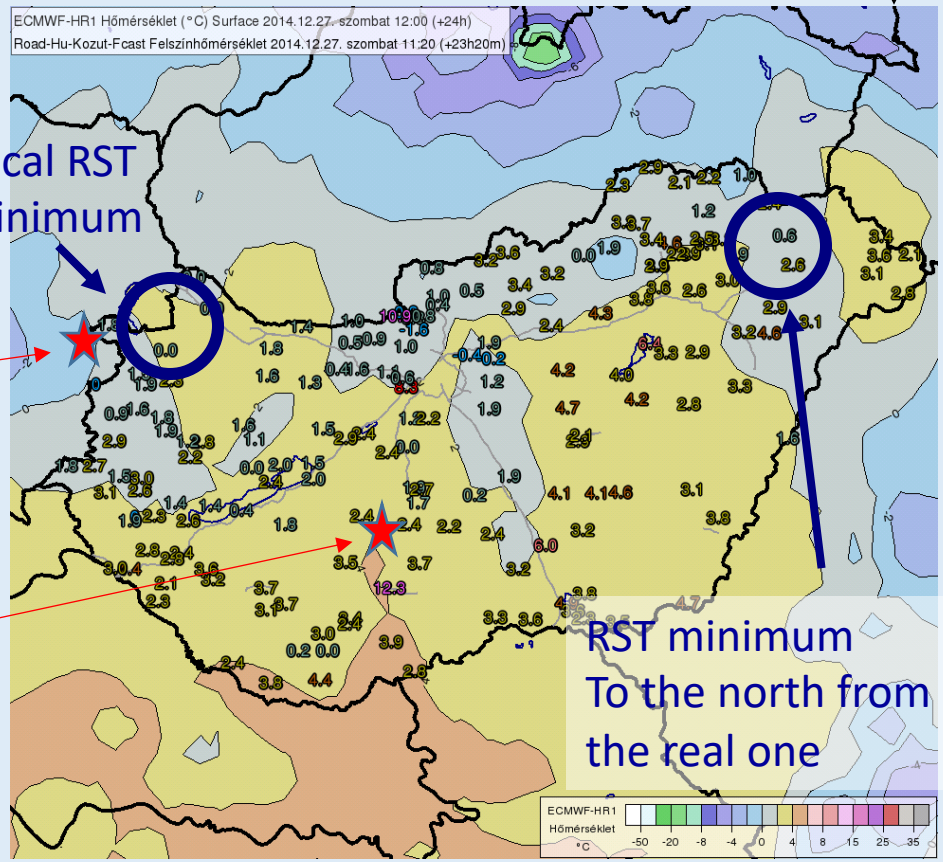
Case studies: Road surface temperature differences

27 December 2014 at noon

- Areas with snow: Northwest and East of Hungary – local minima in RST at noon

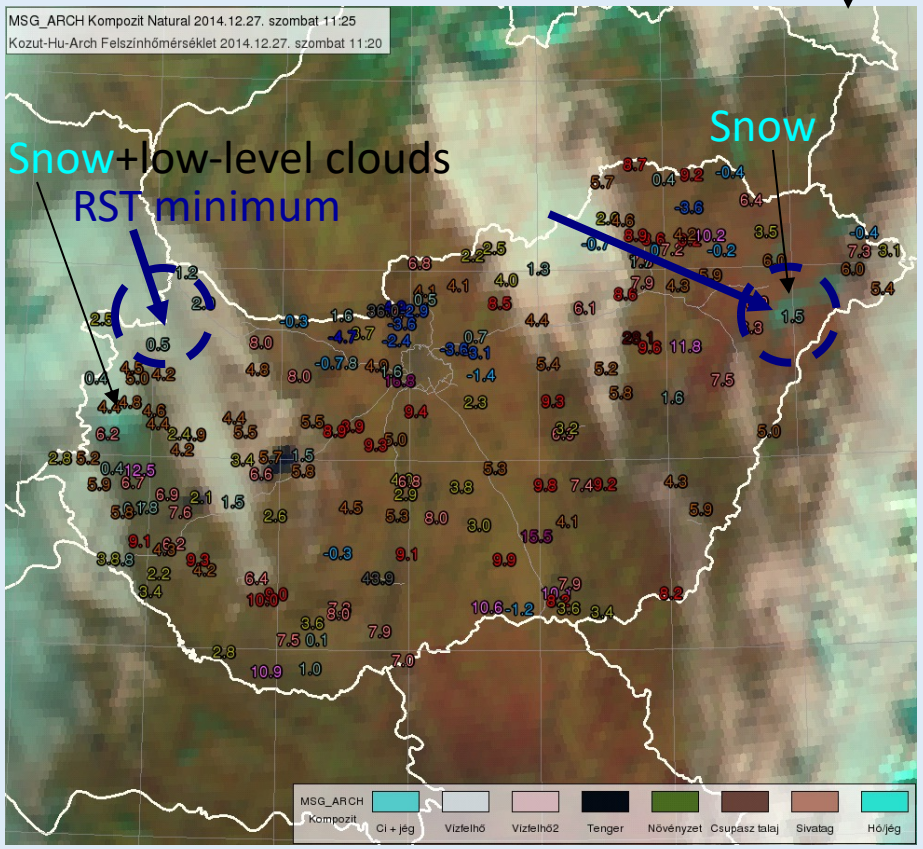
ECMWF surface temperature (shaded)

Forecast METRo (numbers)



MSG satellite RGB composite (Natural Color)

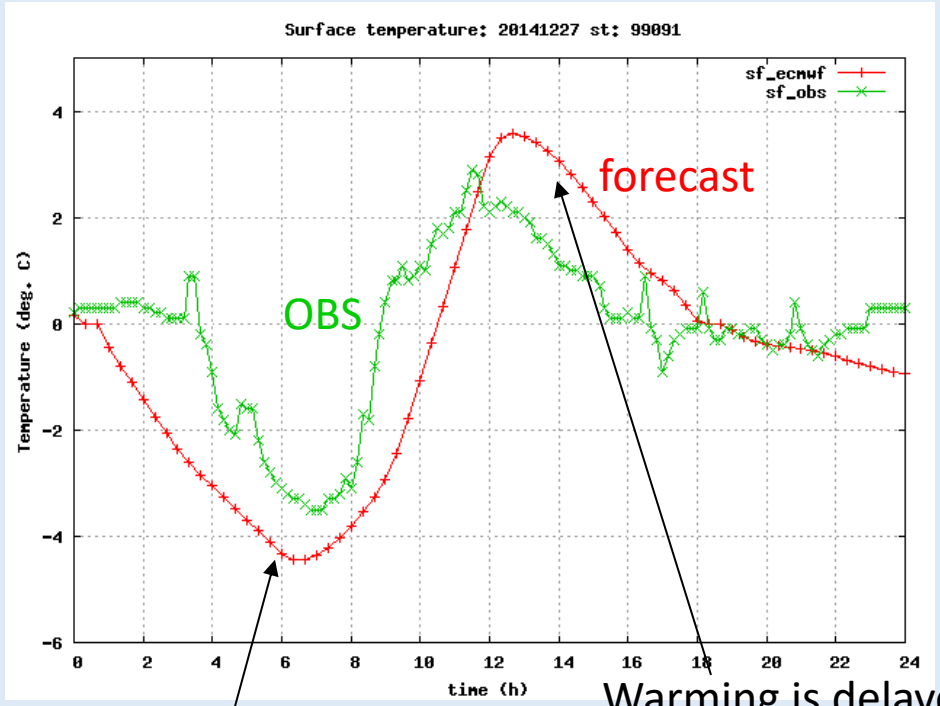
Observed RWS data (numbers)



Daily course of the road surface temperature: 27 December 2014

• Cloudiness has a large influence on the forecast daily course of RST. This is situation dependent and most pronounced at noon. There are systematic errors as well (probably stronger outgoing radiation in the input models, etc.).

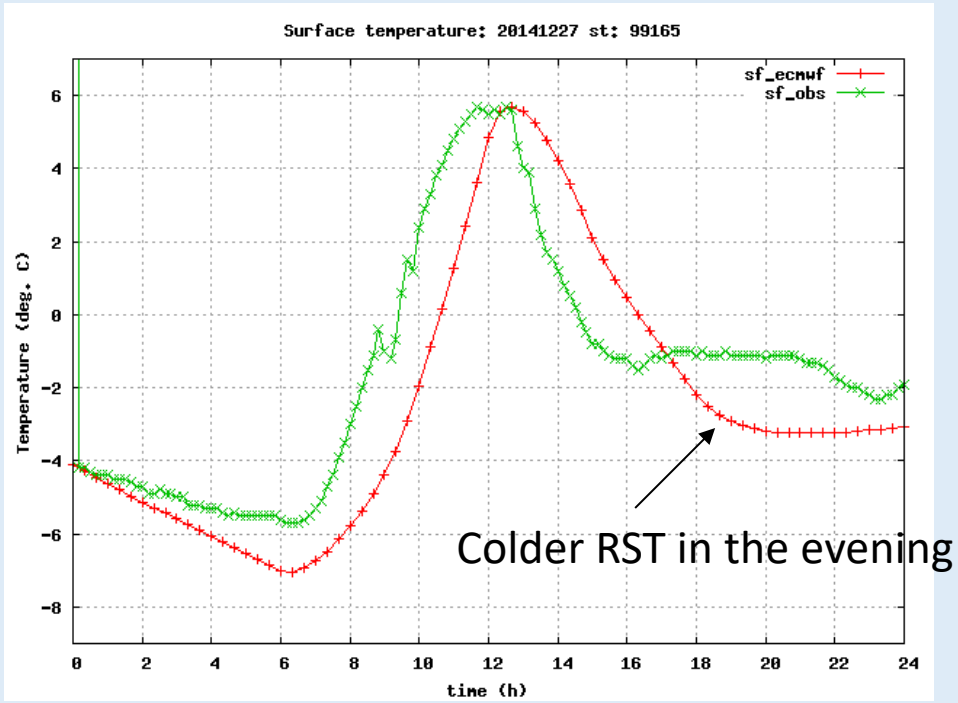
Cloudy weather **Sopron**



Faster cooling at morning

Warming is delayed
and the maximum is higher

Sunny weather **Paks**



Colder RST in the evening

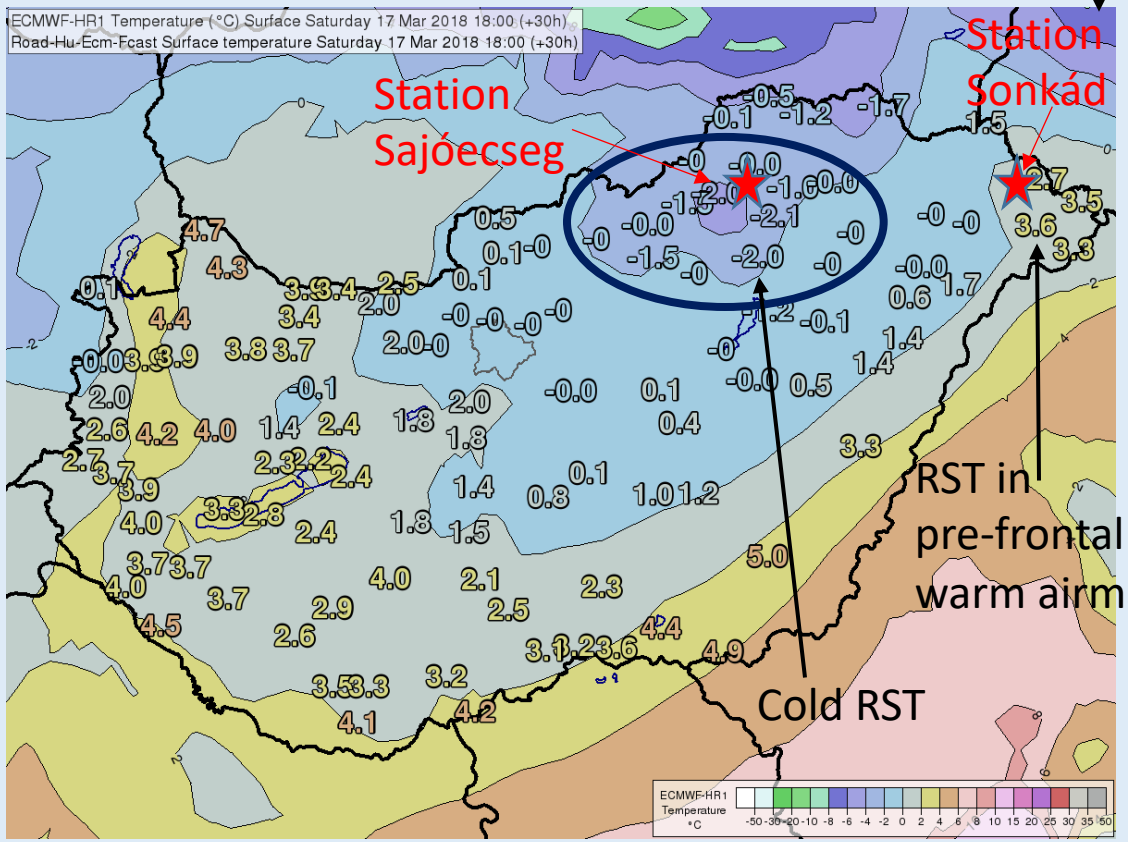
Cold air outbreak from the Northeast

17 March 2018 in the evening

- Heavy precipitation of different types, strong wind in the East of Hungary – icing, blowing snow

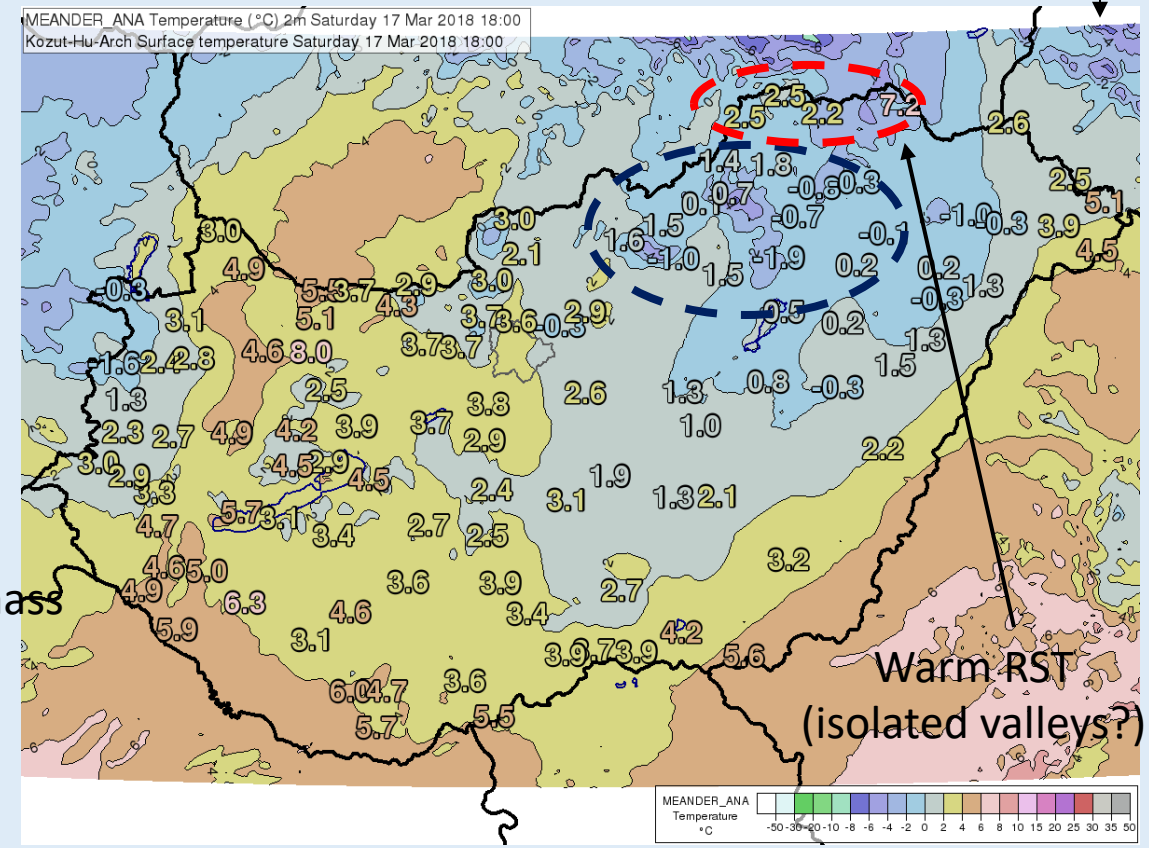
ECMWF surface temperature (shaded)

Forecast METRo (numbers)



MEANDER 2m temperature analysis (shaded)

Observed RWS data (numbers)

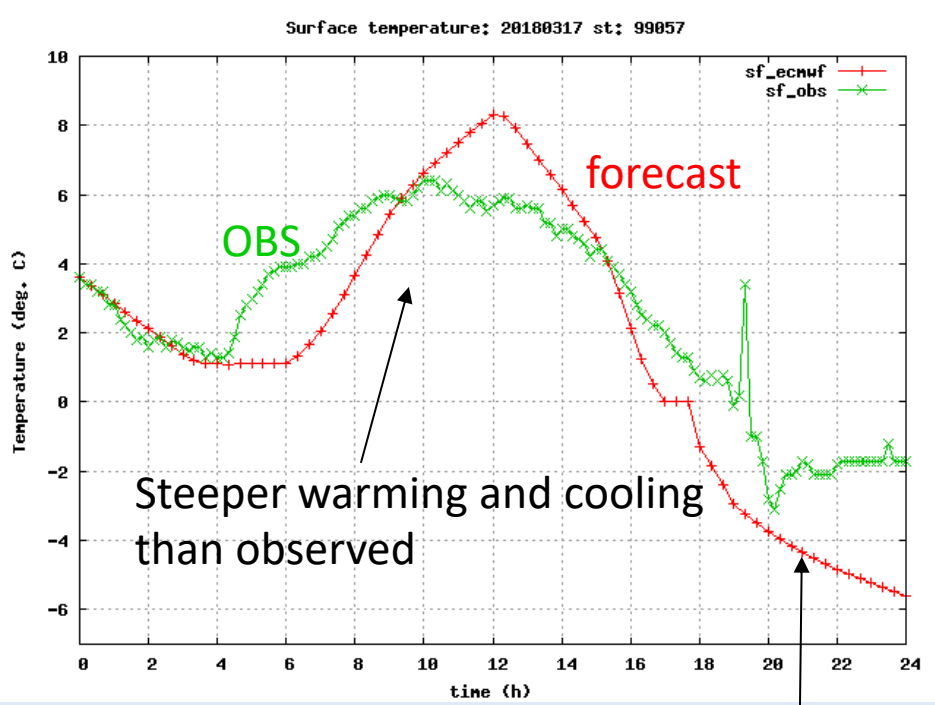


Daily course of the road surface temperature: 17 March 2018

- The forecast and observed temperature tendencies are similar, even in a complicated situation with significant temperature drop and heavy precipitation. The model matched the differences in the RST course in different airmasses.

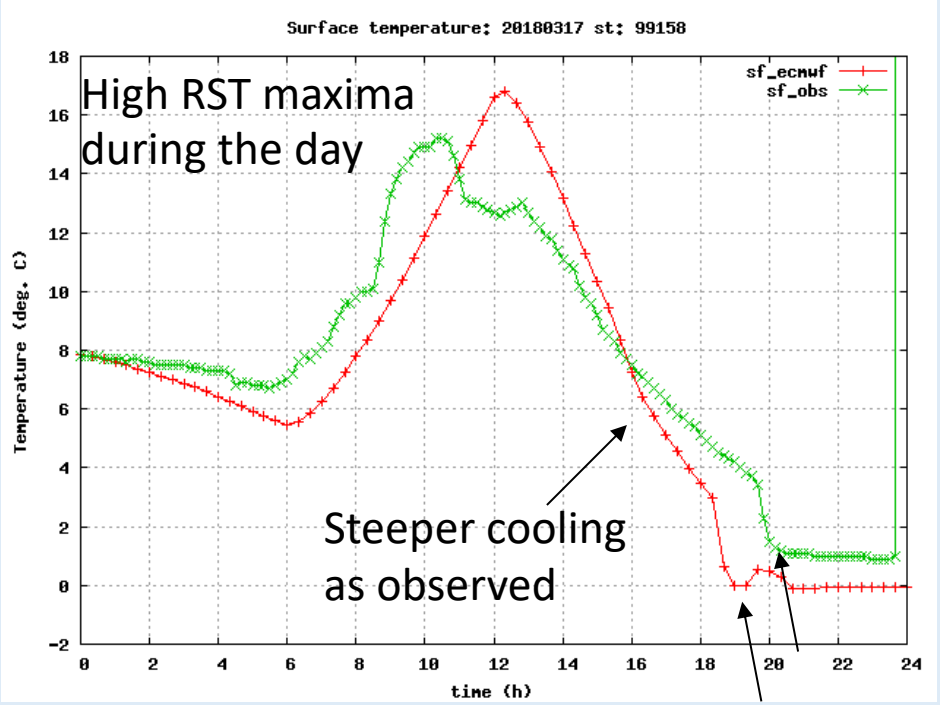
Cold airmass

Sajóecseg



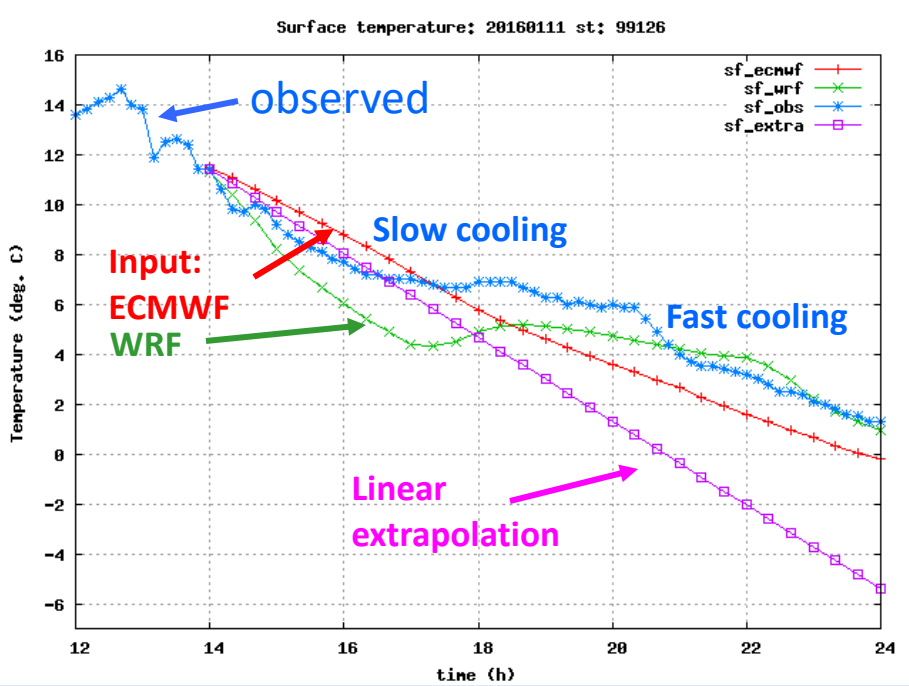
Warm airmass

Sonkád

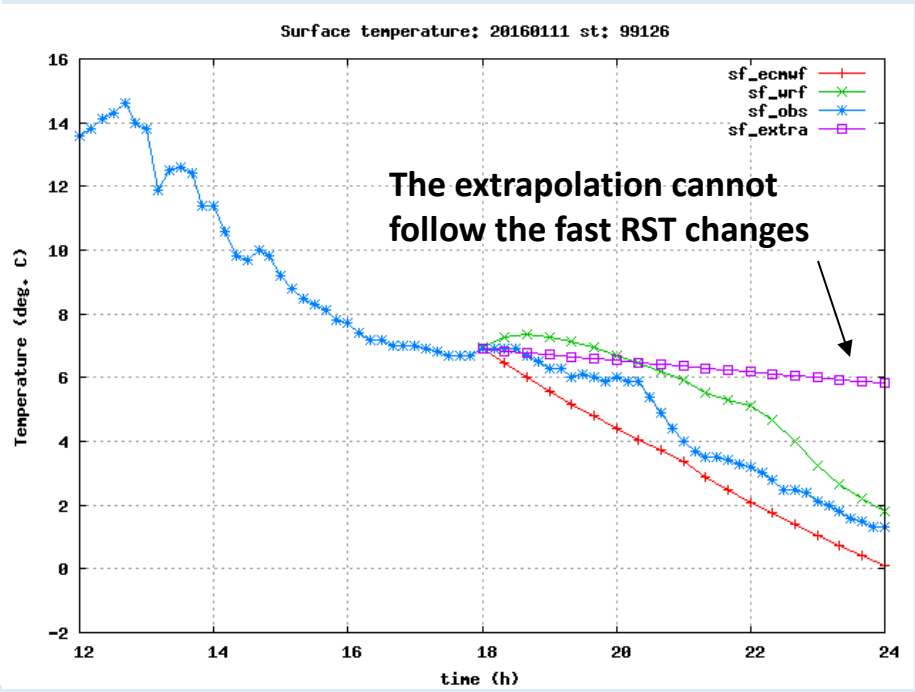


Tests with very short range forecasting of RST

- METRo input: NWP forecasts corrected upon recent OBS, 0-12h run
- Extrapolation: useful at most for 2-3 h, high variability of the tendencies
- The road model forecast is more balanced, runs with LAM model inputs are better in forecasting sudden changes of the road surface temperature



1400 UTC run



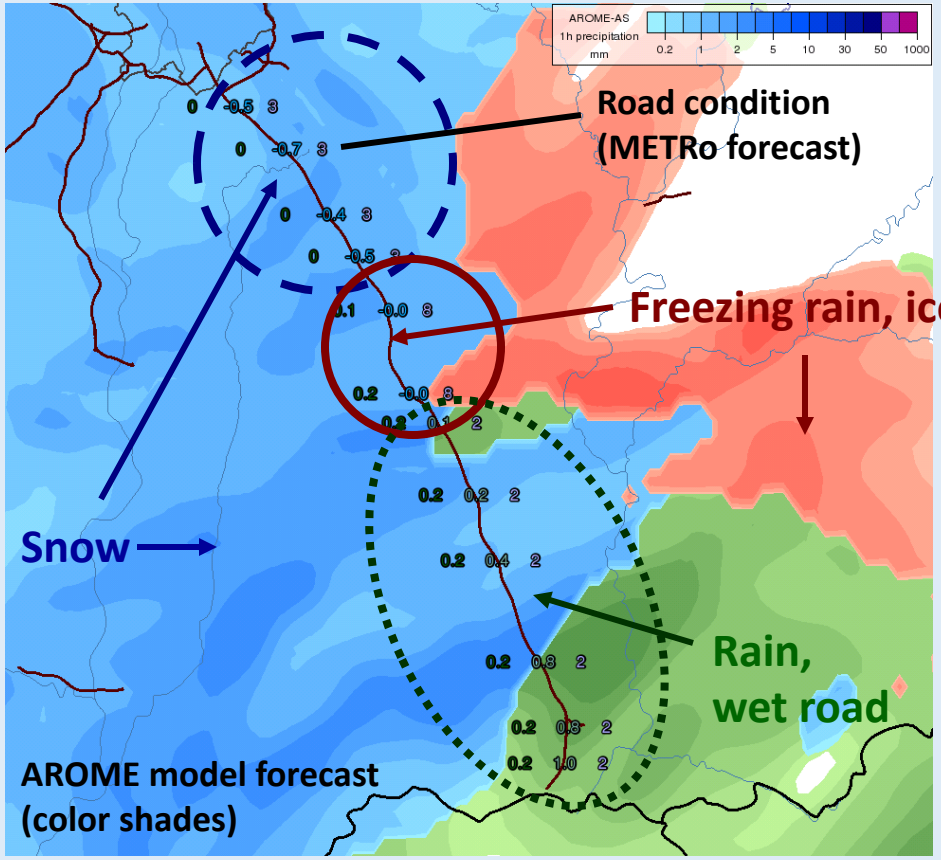
1800 UTC run

Precipitation type, road condition

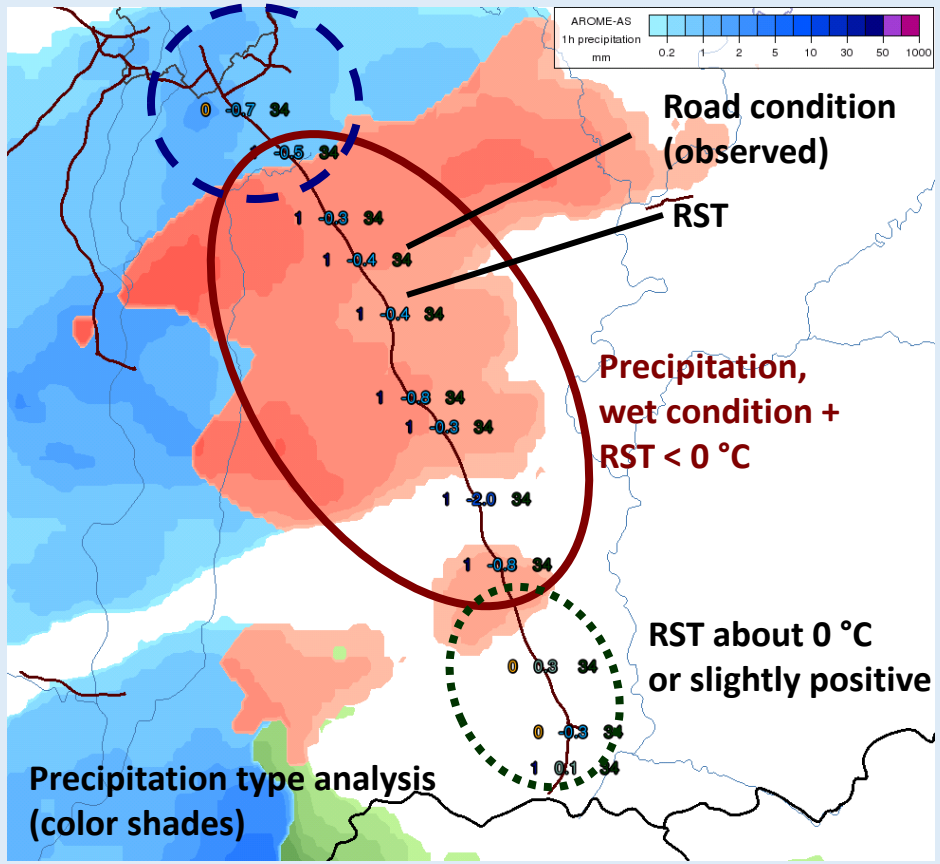
• The OMSZ has developed its own diagnostic method to forecast the precipitation type, which has been applied to NWP model outputs (e.g. AROME, ECMWF). However, this uses the temperature of 2m and higher levels. Forecast with RST could be more accurate for the roads.

M5 motorway experiment:

2016.01.06. 20:00 UTC forecast



2016.01.06. 20:00 UTC analysis



Blowing snow forecasting

- Empirical parameter, Blowing Snow Index (BSI) has been developed to indicate occurrence and intensity of such events (Somfalvi-Tóth et al., 2015)

$$BSI = f(T)+f(T_s)+f(U)+f(G)+f(H)+f(\rho_H)$$

2m temperature

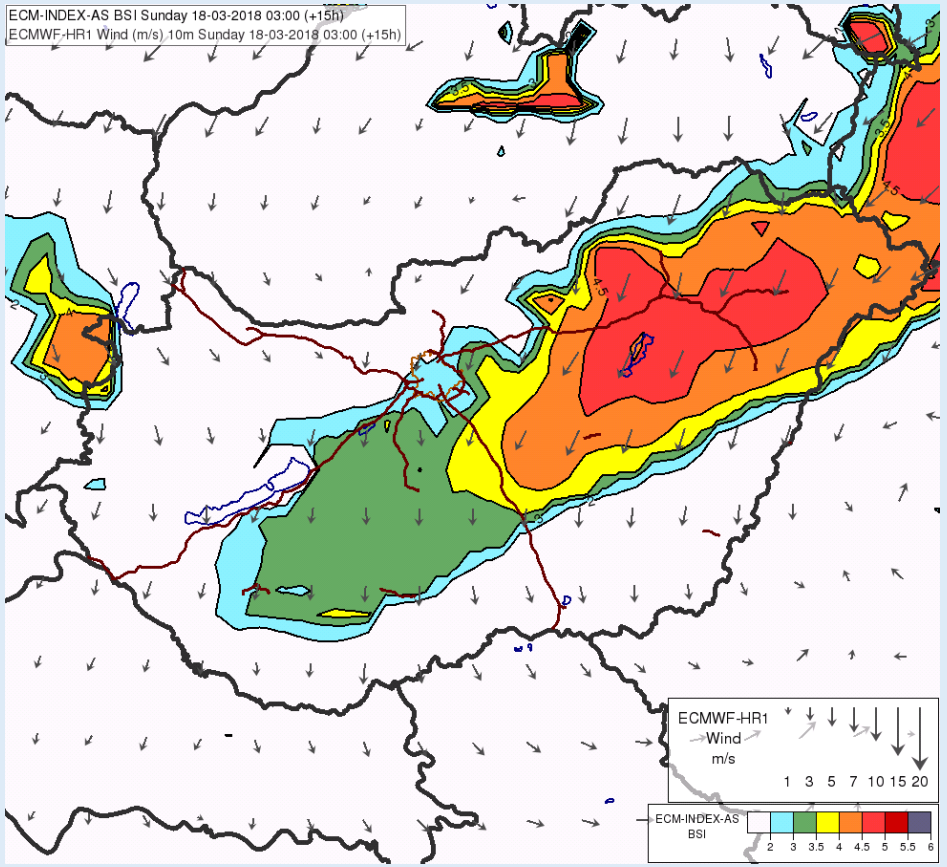
skin temperature

10m wind speed

wind gust

snow depth

snow density



BSI forecast for the 17-18 March 2018 cold air outbreak upon ECMWF model inputs

Conclusions, plans

- High sensitivity of the predicted RST or other parameters on the quality of the input NWP forecasts – improvement through EPS or MOS use possible

- More focus on the high-resolution (2.5 km) LAM inputs (e.g. the AROME model)

- Quality control of input RWS data is important

- Possibility to predict significant RST changes (drop) in difficult weather conditions

- Currently, the use of the road model in everyday forecasting would be possible but correct interpretation of the outputs needs experience and good knowledge of the meteorological models and processes in the backgrounds

Thank you for your attention!